

University of Cambridge
School of Agriculture Memoirs

Memoir No. 25

A summary of the papers published by the members of the Staff of the School of Agriculture and its Associated Research Organisations during the period Oct. 1st, 1952—Sept. 30th, 1953.

Review Series

No. 8. Animal Production Research
at Cambridge.



CAMBRIDGE
1954



FOREWORD

This Memoir, which is published under the general editorship of the Librarian of the School, represents an attempt to present as succinctly as possible the contributions made by members of the Staffs of the School of Agriculture and its Associated Research Organisations to the development and progress of Agricultural Science, to indicate to research workers interested the Journals in which the full papers are presented and to act as a complete record of papers published. Each summary is compiled by the author of the paper and is presented, so far as the subject matter will allow, in a non-technical form in order to be of value to the general body of farmers interested in the more recent developments of agricultural scientific research in general and of the activities of this Department in particular.

Requests for further information or criticism arising out of the summaries should be referred to the individual author concerned, criticisms and suggestions for the improvement of the Memoir itself should be addressed to the Librarian of the School.

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ANIMAL PRODUCTION RESEARCH AT CAMBRIDGE*

By

JOHN HAMMOND, C.B.E., M.A., F.R.S.

(*University Reader in Agricultural Physiology*)

As accounts by Marshall (1947) of work on the physiology of reproduction, and by Halnan (1950) on animal nutrition research have already appeared in these Memoirs, the scientific aspects of these will not be dealt with in detail here, but reference will be made only to some of their applications to animal production.

One of the difficulties which research in animal production has had to face is that of insufficient accommodation and space to keep animals. In the early days of the School most of the animal experiments were carried out on Professor T. B. Wood's own farm in Norfolk. Later, about 1910, when the University Farm at Gravel Hill was acquired many experiments which were of such a nature as not to jeopardise the commercial working of the farm were carried out there. The more drastic experiments were done on the very limited acreage and in corrugated iron buildings of the Field Laboratories at Milton Road, which were shared by four University departments requiring experimental animals. The cost of this was provided by the Ministry of Agriculture as a grant to the Animal Nutrition Institute which was set up at the School of Agriculture about 1911. About 1932 when space at the Field Laboratories was required to house an Animal Pathology Research Laboratory the site was vacated and some 20 acres of land was allocated from the University Farm to set up an Animal Research Station, the buildings and laboratories being provided by the Empire Marketing Board. When, after the 1939-45 war, the Animal Nutrition Institute was broken up these premises were taken over, and added to by the Agricultural Research Council's Unit of Animal Reproduction. Since that time various small pieces of land have been hired or obtained on loan to carry the experimental animals required.

Following Bateson's re-discovery of Mendel's laws of inheritance and their practical application to plant breeding by Biffen, Wood set up an experiment to test their application to farm animals. As there was no accommodation for this at the small University Farm at Impington, this experiment was carried out at Wood's own farm in Norfolk. By crossing the polled black-faced Suffolk sheep with the horned white-faced Dorset Horn it was shown (Wood, 1905) that the recombination of black horned and white polled occurred in the F_2 generation. When the University Farm was moved to Gravel Hill on the Huntingdon Road, and there was more accommodation, an attempt was made to see whether these laws of inheritance also applied to commercial characters such as wool and mutton. Thanks to Mr. Hawker, two South Australian Merino rams were sent over and were crossed with Shropshire ewes, the best mutton breed of that time. The experiments were carried out by Mackenzie, Director of the University Farm, and Marshall, who had recently joined the Department as Physiologist. It was soon realised that not much progress could be made in this field until much more knowledge was obtained concerning exactly what did constitute good wool or good mutton qualities in the animal. Two research students working at the newly formed Animal Nutrition Institute were therefore set to work on these problems. Bailey studied wool quality in conjunction with Barker of the Textiles Department of Leeds University, and the writer studied meat qualities in conjunction with Appleton of the Department of Anatomy in Cambridge. This experiment and all the work connected with it was shattered by the onset of the 1914 war, during which Bailey was killed and the flock had to be slaughtered. Some results, however, concerning the inheritance of mutton qualities (Mackenzie & Marshall, 1917) and on factors affecting wool quality (Bailey & Engledow, 1914) were obtained and published. These experiments formed the basis for work on both meat qualities (see below) and wool which were continued later. In 1935, during the course of the establishment of an inbred strain of Suffolk cross sheep, it was noticed that there was marked segregation of wool qualities which were associated with marked differences in the tails of the lambs, these providing a good index of the spread of the best wool found on the shoulder outwards over the whole body (Thomasett, 1938). Lambs' tails from many different breeds were examined and were found to be a good index of the wool qualities of those breeds (Bhattacharya & Hammond, 1952). In conjunction with the Wool Industries Research Station at Leeds, and with the financial assistance of the International Wool Secretariat, Romney Marsh sheep were inbred and selected along two different inbred lines on the basis of the difference (hairy or woolly) of the tail at birth, and these have resulted in true breeding strains not only for these characters but also for bad or good wool distribution qualities respectively in the adult fleece (Hammond, 1952a). This is a method of selection for wool qualities which does not require expert technical knowledge and can be carried out by the farmer himself.

To extend the application of genetics to the animal industry work was also undertaken in small animals where results could be obtained more quickly. The first problem investigated was that of the inheritance of body size in poultry and rabbits (Punnett & Bailey, 1918), and work was begun on sex-linked characters in poultry which led to the commercial practice of making sex-linked colour crosses so that the pullets could be picked out at hatching (Punnett, Warren & Hutt, 1930). This work was carried out in a Small Animal Breeding Research Unit under Punnett; later it was merged with the Animal Nutrition Institute and when this latter was broken up in 1946, it continued under Pease as a Poultry Research Station. Among other things Punnett (1930) showed that high egg production was not a sex-linked character and he and Pease (1930) produced an auto-sexing pure breed, the Cambar, which was used by Pease (1952) to produce auto-sexing strains of the

*This is the eighth of a series of articles summarising phases of agricultural research particularly associated with the School of Agriculture since its inception, previous contributions having dealt with:—Physiology of Reproduction, Plant Virus Research, Plant Breeding Institute, Animal Nutrition, Horticultural Research Station, Agricultural Economics, and Field Drainage. Further contributions on other work will appear in future issues.

breeds in common use (Legbar, Buffbar, etc.). Such breeds were found most useful during the last war when sufficient feeding-stuffs were not available to rear cocks as well as pullets. Pease (1950) both here, and in conjunction with the Poultry Research Station at Reaseheath in Cheshire, also developed inbred lines and made crosses between them. Recently a return has been made to the original problem of breeding dual purpose animals by studying the inheritance of high egg production and meat qualities in crosses between these two types; results are not yet available.

During the 1914-18 war, Wood's connection with the Ministries connected with food production and consumption, and particularly with the Army Cattle Committee, gave direction to research connected with the immediate national problems. Mackenzie & Marshall (1918) by dissection and analytical methods showed that there was a high correlation between the carcass percentage of bullocks and the composition of the carcass in terms of fat, muscle and bone. After the war was over Wood and Newman (1928) continued this work with particular relation to the amount of nutrients consumed per lb. of edible meat produced. Incidentally this led to a study of the effects of hanging meat to improve the quality of inferior carcasses and joints, and the establishment of the Low Temperature Research Station under Sir William Hardy at Cambridge. Wood and Newman's results showed that the young animal was a much more efficient converter of feeding stuffs into meat than the old animal, 1 lb of edible beef being produced from $11\frac{1}{2}$ lbs of dry matter in the feed of animals slaughtered at 1½ years old, whereas it took $22\frac{1}{2}$ lbs of dry matter in the feed to produce 1 lb edible meat from a 3-year old bullock. The young animal did, however, require more concentrates ($2\frac{1}{2}$ lbs) than the old one ($1\frac{1}{4}$ lbs). This led Wood (1917) to study the national aspects of the relative supplies of home-grown concentrates and roughages available for feeding cattle, and he considered that it was necessary to increase the former and reduce the latter. Confirmation of this point of view was obtained from coincident studies of milk records (see below) where it was found that milk production increased greatly when cows were turned out to young grass in the spring, but fell as the grass got older (Hammond & Sanders, 1923; Sanders, 1928). Confirmation was also obtained from growth studies in lambs made on the University Farm where it was shown that it was the stage of growth at which the forage crop was consumed rather than the variety of forage crop which determined the rate of growth made (Hammond, 1932a).

In order to preserve the crop at an early stage of growth for use throughout the year Amos and Woodman (1925) undertook a series of experiments on silage making, a practice which at that time was but little used in England. Woodman and others (1926) also showed that the reason why young grass was so good for growth and milk production was that it was high in proteins and minerals and low in fibre. The dried grass cakes which they produced and fed experimentally showed that a home-grown high protein feeding stuff could be produced to take the place of the imported high protein cakes. This formed the basis on which the modern system of grass drying developed.

Between wars, at the time when owing to unemployment there was a world surplus of meat, work was directed to improving the quality of meat (see below), and so far as beef was concerned experiments were set up on the University Farm to find out the best method of producing good quality beef from the inferior dual purpose heifers which at that time were coming in large numbers from Ireland. These were crossed at the University Farm with different breeds of beef bulls and the value of their carcasses assessed (Hammond & Mansfield, 1936). It was found that the best results were obtained by mating a shelly, light-boned cow with a strong-boned bull and a strong-boned cow with a fine-boned bull. These results were made use of at the end of the 1939-45 war when it was required to produce good beef from the inferior cows of a swollen dairy industry. By this time Artificial Insemination (see below) had developed throughout the country and so made possible the widespread use of Hereford and Aberdeen Angus bulls on inferior dual purpose cows; these breeds, in addition to being strong and light-boned respectively, had dominant colour markings and so colour-marked the crossbred calves which prevented them getting mixed with the dairy bred stock (Hammond, 1944, 1949). To reduce the costs of rearing, as compared with the 1 cow 1 calf system of beef breeds, and at the same time to improve the plane of nutrition on which the calf was reared as compared with the bucket feeding system generally used, a method of multiple suckling by which a dual purpose cow could rear up to about 10 calves was developed on the University Farm (Garner, 1946).

During the 1939-45 war the results of Mackenzie's and Marshall's (1918) research on cattle in the 1914-18 war were made use of and cattle were graded and sold on a carcass percentage basis. In order to find out how the prices then arbitrarily fixed for the different grades corresponded with the real food value of the carcass Callow (1944) of the Low Temperature Research Station, Cambridge, and the writer obtained cattle of different grades, dissected and analysed them. The results showed that the higher grades as compared with the lower grades, were being purchased for less than their true food value, and this was subsequently adjusted in price reviews. This and other similar investigations on sheep and pigs (see below) have shown how the complicated problems of meat composition can be simplified and used for the purposes of calculations of national production or consumption (Callow, 1948). As during and after this war the supply of imported concentrated feeding stuffs was cut off and their cost was high, the problem of how those limited supplies could best be used for beef production arose. To solve this and other beef production problems Brookes and Vincett (1950) undertook an experiment on planes of feeding (see pigs and sheep below) on the University Farm, and this is still in progress. Sufficient has been done, however, to show that expensive concentrates are most efficiently utilized by the young calf under 8 months old, just as they are in a cow in early as compared with late lactation (Edwards, 1936), and that poor feeding during this early period of the calf's life delays the age of slaughter by a year and so delays the turnover on capital, the main disadvantage of the beef compared with the dairy industry (Hammond, 1946). The high cost of fattening during the winter as compared with the summer as shown by these experiments (Brookes & Vincett, 1950) raises the question of whether, now that we have owing to world shortage to supply meat for the millions rather than select beef for the few, we should not fatten during the summer and cold store meat for use during the winter and spring months (Hammond, 1952b).

After the end of the 1914–18 war, work on what constituted quality in meat was resumed and two separate lines of approach were undertaken—laboratory investigations and what came to be known later as “operational research”. This latter consisted of obtaining a number of facts and figures from the industry, analysing them statistically, and coming to conclusions which were then followed up and tested by accurate laboratory experiments and observations. With the help of Udney Yule and, later, Wishart, University lecturers in statistics, research was undertaken on the growth rate and carcass tests of different breeds of cattle, sheep, and pigs exhibited at Smithfield Show (Hammond, 1920, 1921, 1922), and measurements of these carcasses over a large number of years, gave objective figures for the meat qualities of the different breeds, while comparison of the prize winners with the rest showed what qualities were considered most desirable in a meat carcass (Hirzel, 1939). The prices per lb given for non-prize winning carcasses at the auction sales showed how this varied with the carcass weight and fatness in the different breeds (Hammond & Murray, 1934). Similar work was done on measurement of bacon carcasses of different breeds at the Dairy Show (Hammond & Murray, 1937), and these, in the light of laboratory work on the changes in body proportions with age, enabled breeds to be classified in the order of maturity in body proportions (Hammond, 1932b).

The laboratory work on meat consisted of finding out how the body proportions and composition changed as the animal grew up and then how this change was modified by breed and by nutrition. Correlations were also determined between the eating qualities of meat (flavour, tenderness) and the chemical and histological qualities (colour, muscle bundle size), both in different animals and different muscles of the same animal (Hammond, 1932a). One outcome of this work was the setting up of objective standards by which to judge the quality of a meat carcass (Hammond, 1937, 1952c). The standards so obtained enabled an assessment to be made of the relative meat value of the different breeds and crosses of sheep used in Scotland (Palsson, 1940).

Early in the history of the School, Mackenzie and Marshall (1915) had become interested in the problems of the bacon industry and they instituted a series of experiments on the effects of spaying. They also examined the carcasses for seedy cut which was causing large losses in the industry; this was found to be due to skin pigment which was formed during the early development of the mammary gland in black pigs (Mackenzie, Marshall & Hammond, 1914). Later, as more knowledge concerning the consumer requirements for quality in bacon became available, a point scale partly based on measurement and partly on eye judgement, was set up and used in bacon competitions at the Dairy Show and at the N.P.B.A. and other shows throughout the country. The advantage of this system is that it tells the producer who does not win what the chief faults of the carcass are. Pomeroy (1939–40) has given an account of this scale and some of the results obtained by its use. Similar point scales suitable for frozen pork and bacon pigs coming from New Zealand and Australia were also produced (Davidson, Hammond, Swain & Wright, 1936–7) and modifications of these are now being used there to indicate to the producers the requirements of the London market. A method of Pig Recording which helped the farmer to measure the efficiency of his management, feed conversion, and bacon quality was evolved by Davidson, Duckham and Kitchin (1929–31) and this initiated such societies throughout the country.

As a result of the laboratory studies on the growth of meat producing animals at the Animal Nutrition Institute, it had been shown (Hammond, 1932a) that the different parts and tissues of the body developed in an orderly sequence—head, neck, loin; bone, muscle, fat. Each part and tissue achieves its maximum growth rate at different times during the animal's life and so leads to the changes in the proportions and composition of the body as the animal grows up. The question then arose, could these changes in form and composition be controlled by the farmer. McMeekan (1940) showed in pigs that they could be controlled by changing the plane of nutrition on which the animal was reared at different stages of its life—a high plane stimulating and a low plane inhibiting most, and differentially, those parts which had the highest growth rate at that time. Thus, up to 16 weeks old, at a time when bone and muscle had the highest growth rate, high plane nutrition stimulated and low plane depressed the length, growth and development of muscle, while high plane nutrition later on in life stimulated and low plane nutrition depressed fat formation. Pigs reared on a high-low plane of nutrition produced bacon type carcasses with much lean and little fat, whereas those reared on a low-high plane produced lard type carcasses. It was shown that the different shapes of the live weight growth curves obtained in this experiment were typical of those existing in different counties which were producing bacon or lard type pigs (McMeekan & Hammond, 1940). The practical application of these results in the production of high grading bacon pigs was demonstrated by Mansfield and Trehane (1936) on the University Farm.

A similar series of experiments were carried out by Verges (1939) and Palsson and Verges (1952) on lambs, and they confirmed and extended McMeekan's work on pigs. Among other things, they showed that sex differences are reduced by low plane nutrition. Owing to the fact that the fat lambs are killed at an early stage of life, a high-high plane of nutrition gives the best, and a low-high plane the second best, carcasses. From these and other similar experiments and observations (Hammond, 1933–34; McMeekan & Hammond, 1940) two important points emerged, (a) the significance of the environmental and nutritional conditions under which the animal was reared for the expression of the inherent genetic capabilities of the animal for meat production (Hammond, 1947), and (b) that the partition of the incoming nutrients in the blood stream to the different parts and tissues of the body was determined by the metabolic rate of the part and tissue, and the relative amount of incoming nutrients going to each part, could be influenced by the plane of nutrition. As an example of this latter point Wallace (1948) showed that while in early pregnancy the foetus had priority of supply and its size was not affected by the plane of nutrition of the ewe, during the last 8 weeks of pregnancy owing to the senility of the placenta, this priority of supply was lost and so the weight increase of the lamb was directly dependent on the plane of nutrition of the ewe. Wallace's experiments showed why it was that large losses in lambs and also of the ewes frequently occurred in hill sheep, for with them lambing occurs after the worst nutritional conditions of the year, and so the lambs are born in an under-developed state in which the heat regulating mechanism of the body is not fully developed (Hammond, 1952a). Moreover, he

found that reduced nutrition during late pregnancy led to the accumulation of fat in the liver to such an extent, especially in twin-bearing ewes, that it often caused pregnancy toxæmia and death of the ewe, the supposition being that under reduced planes of nutrition the demands of the embryo for sugars in the blood was so high that not sufficient was available for the breakdown of fats in the liver. Considerable losses to the sheep industry are caused by this disease, especially during unfavourable spring months.

After the 1914-18 war, and before the National Institute for Research in Dairying was founded, milk production was becoming an important industry, and so research was commenced on the various factors which affected milk production. The pattern of research adopted was to undertake operational research by a statistical study of milk records made in two different areas, Cumberland and Westmorland (Hammond & Sanders, 1923) and Norfolk (Sanders, 1928), and to test out the conclusions arrived at by laboratory experiments. Among other things, the operational research showed that there was a marked drop in milk yield at about the 20th week of pregnancy, while laboratory work showed that in heifers pregnant for the first time, the alveoli of the gland began to grow in preparation for the next lactation at this time (Hammond, 1927). At this time a thick honey-like secretion consisting largely of globulins was secreted (Woodman & Hammond, 1923; Asdell, 1925) which, mixed with the milk which was formed later, gave rise to colostrum. It was shown later (Hammond, 1936b) that the composition of the normal milk of different species was similar to some of the transitional stages of formation in the cow. Sanders (1928) also showed how the lactation yield increased with age up to the 5th lactation and then began to fall, and how a dry period before calving increased yields in the next lactation, and especially in the 2nd lactation, for heifers tend to have a persistent lactation compared with older cows. He found (1930) also that persistency of lactation varied with the breed, and that (1927) the optimum calving interval for milk production increased as yield increased. The effects of time of year on milk yield were worked out for the two areas; this showed the influence of young grass on yield, which has already been referred to above. Experiments on butter fat secretion were also made, and it was shown (Hammond & Hawke, 1917) that reduced nutrition or lowering of the sugars by injection of phloridzin while it decreased the milk yield increased the percentage of butter fat in the milk. Garner and Sanders (1938) also showed that by feeding butter, or the margarine oil cakes, the fat percentage could be increased slightly, but that other oils like linseed or cod liver oil lowered the fat percentage of the milk. On the operational research side statistical studies on records made at the Dairy Show (Whetham & Hammond, 1935a) showed that with a constant milk yield the fat percentage varies between breeds, but not to the same extent as it does when no account is taken of the differences in average yield of the different breeds. An analysis was also made (1935b) of the factors which affect the colour of the butter fat in the different breeds. Edwards (1950) later found from a statistical study of herd records how the butter fat percentage varied with yield, time of year, time of day, and other factors; he related them not only to the secretion but also to the "let down" of milk and under pressure, the importance of which had previously been drawn attention to by Hammond (1936a).

Edwards (1932b) also studied the best method of calculating the progeny record of a bull for milk yield, and concluded that formulas which took into account the yields of the dams gave less accurate results than the actual average yields of the daughters. This method has now been adopted by National Milk Records in their lists of Progeny Tested Bulls. This study also showed that the bull used was often responsible for the production of low yielding heifers in herds where the practice of culling for low yields had taken place over a large number of years, and led to the conclusion that better selection of the bulls used in dairy herds would do more to increase milk yields than would the expensive system of culling the low yielders (Hammond, 1944, 1949, 1950a). Sanders (1928-30) had previously studied the causes of wastage of cows in dairy herds by collecting data from milk recorded herds; he found that the two principal causes were low yields and sterility. He also showed that the average herd life of a cow was only about $2\frac{1}{2}$ lactations. These results of operational research have led to concentration of research on methods of breeding for high milk production, and on cow sterility (see below).

Just before his death, Wood went out to the West Indies and saw the difficulties of producing milk in the tropics from breeds which milked well in this country. On his return, the writer was sent out by the Empire Marketing Board to investigate these difficulties. It was found (Hammond, 1932c) that European cattle had a constitution unsuited to high temperatures but that when this was added, by a cross with Zebu cattle, high milk yields were obtained (Edwards, 1932a; Hammond, 1931); the Zebu however had a factor for not "letting down" their milk, which, however, could be bred out. Later it was shown by other workers that tolerance to high temperatures was an inherited character and much work is now in progress in different research institutions to determine the physiological cause for tolerance to high temperatures. An analysis of the factors which have to be considered in the adaptation of livestock to new environments has been published recently (Hammond, 1951).

One of these environmental conditions on which considerable research has been undertaken at Cambridge has been the effect of length of daylight hours on fertility. It had been shown in small animals such as the ferret (Marshall, 1936) that the breeding season is controlled by this factor, and that it also determines the rate of egg production in the fowl (Whetham, 1933), both these species responding to long light—short dark days. Burkhardt (1947) showed that by added electric light after dark during the winter months mares would begin breeding much earlier in the spring than those not so treated. Yeates (1949) demonstrated that autumn breeding animals such as the sheep responded to long dark—short daylight hours, and by this means could be made to lamb during summer and autumn so as to obtain at any rate three crops of lambs in 2 years. Hart showed for both ferrets (1951) and sheep (1950) that, by breaking the long night or day by a short period of light or dark respectively at the centre of the period, breeding could be induced in the non-breeding season. In Suffolk sheep it was shown that the breeding season was equally spaced each side of the shortest day with a high peak of fertility, i.e. highest lambing percentages, occurring from matings during the first week in November (Hammond Jnr, 1944). Hafez (1952) followed up this work by determining the length of the breeding

season in some six very different breeds of sheep and found that the length of the breeding season decreased with the increase in altitude or latitude of their origin. Experiments in controlling daylight hours in these breeds show that they varied in the latent period between the onset of the dark stimulus and the appearance of heat, those from higher latitudes requiring the longest time. These studies have made it possible to predict which of the British mutton breeds of sheep are capable of lambing at the times required in various parts of the world where rainfall conditions require lambing outside the normal spring months; they also show the cause for the frequent temporary sterility of sheep exported to the southern hemisphere, that is when export takes place from a short day to a long day environment.

By about 1936 scientific knowledge concerning the reproductive hormones and their assay appeared sufficiently advanced to warrant an attempt to apply them to problems of animal production. A study of reproduction in the mare (Hammond, 1938; Hammond & Wodzicki, 1941) had shown that owing to delayed ovulation and the length of the heat periods, the sperm might perish before the egg was shed and for this reason the variations in the fertility of premium stallions was very large (Sanders, 1926). In conjunction with the Agricultural Research Council and the Thoroughbred Breeders' Association, a small experimental stud was set up in Newmarket, and mares which had been sterile for three seasons were accepted for study and return to their owners when got in foal. Various causes for sterility were found and overcome (Day, 1939a), and among others it was found that ovulation could be caused within 30 hours by intravenous injections of L.H. (Day, 1939b), so that if made at the time of mating or insemination it would ensure optimum conditions for fertility (Davison, 1947). Methods of early pregnancy diagnosis by rectal palpation were also developed (Day, 1940) which enabled pregnant mare serum hormone (P.M.S.) to be collected from mountain ponies (Day & Rowlands, 1940) to provide comparatively cheap supplies of this potent ovarian stimulant for use in cattle and sheep.

With the onset of the 1939 war, the experimental stud had to be given up and the work on horses discontinued. It was resumed, however, afterwards by the Equine Station of the National Health Trust. During the war the personnel were switched over to similar work with cattle, and facilities were very kindly put at our disposal by Lord Iveagh at Elveden in Norfolk for the study of cattle sterility in his many herds of dairy cattle there; other breeders in the vicinity of Cambridge also gave similar facilities. Among other things, it was discovered that injections of P.M.S. were useful for overcoming the winter anoestrus which frequently prevented young cows and heifers from coming on heat at a time when it was necessary to serve them to ensure a winter milk supply (Bhattacharya, Hammond Jnr, & Day, 1941). At this time the newly discovered synthetic oestrogen, stilboestrol, became available, and preliminary experiments on the University Farm having shown that implantation of tablets under the skin caused maiden heifers to come into milk, it was used in Lord Iveagh's herds to bring into milk for the next autumn heifers which had failed to get in calf during the winter months (Hammond Jnr & Day, 1944). During the war period when winter milk was scarce, this was carried out on a considerable scale throughout the Eastern Counties (Day & Hammond Jnr, 1945) and, as many of these became pregnant during the following winter, well-bred heifers were kept in the dairy industry instead of being sent to the butcher (Hammond, 1948a).

The effectiveness of injections of P.M.S. in ripening follicles in the ovaries led to attempts being made to cause superovulation and the production of twins in beef breeds (Hammond Jnr & Bhattacharya, 1944; Hammond Jnr, 1949), and so of reducing the cost of breeding beef cattle. This could be done experimentally by injections on the 17th day of the cycle, but the difficulties of determining when this was in beef cattle have so far prevented it being used in practice. Rowson and Lamming's (1953) method of injecting it after squeezing out the corpus luteum seems however to offer practical possibilities. Preliminary experiments with rabbits showed that superovulation could be exploited by transplanting the fertilised eggs to other females, about 80% of the eggs transplanted directly producing normal young (Dowling, 1949); and even when flown in cold storage across the Atlantic in the 4-cell stage normal young were produced (Marden & Chang, 1952). The best methods of superovulating cows, in which as many as 25 fertilised eggs could be obtained at one heat period, was investigated by Dowling (1949) and Rowson and Dowling (1949), and they also invented an apparatus for washing them out of the living cow. All their attempts at transplanting the eggs by insertion through the cervix failed (Lamming & Rowson, 1952), although it has been done successfully in U.S.A. using the method employed in the rabbit, i.e. an operation and insertion into the fallopian tube. If transplantation could be achieved without an operation it would enable dairy cows to produce beef calves and increase the number of calves which could be produced from a cow of good genetic worth (Hammond, 1950b). It was found by Marden (1952) that calves could be superovulated soon after birth, so that it should be possible when methods of transplantation are developed to reduce the time between generations in cattle. The reason for failure has recently been found to be that, although at heat when the uterus is under the influence of oestrogens the cow can be inseminated into the uterus without any infection taking place, when this is done after heat is over and the uterus is under the influence of progesterone, infection of the uterus invariably occurs (Rowson, Lamming & Fry, 1953a, b). This finding explained other facts previously found, e.g., that squeezing out the corpus luteum at mid cycle was an effective method of curing many causes of sterility (Marshall & Hammond, 1925), and that spontaneous recovery from trichomonas infection frequently took place if a period of oestrus was allowed to occur before service (Laing & Day, 1947), and that in mares which sucked air into the uterus it became infected, and this could be cured by suturing the lips of the vulva but not by washing it out (Day 1939a). Lamming and Rowson (1953) have recently found that the effects of an active corpus luteum and progesterone in making the uterus of the cow susceptible to infection can be overcome by injections of 100 m.g. stilboestrol.

The use of P.M.S. was also tested on sheep, not only to cause superovulation (Hammond Jnr, Hammond & Parkes, 1942), but also to get the ewe to breed during the non-breeding season. The best results were obtained by repeating the injection at an interval of 12 days; although some success was obtained the results

so far are not uniform enough for it to be used in practice (Hammond Jnr, 1945 ; Robinson, 1950) and further work is necessary. The results of attempts to increase the lambing percentage within the breeding season showed more promise. While high doses caused large numbers of eggs to be shed, a large number of embryos degenerated and gave a lower percentage. Small doses (450 i.u.) however raised the lambing percentage from 147% to 167% in the small experimental flock (Robinson, 1951). Throughout these experiments on sheep and cattle, large numbers of animals were used for short term trials through the co-operation of the Ministry of Food ; females purchased for slaughter were injected at the times required, the Animal Research Station being used as lairage, and slaughter was postponed according to the needs of the experiment.

About 1920, work was begun on the application of Artificial Insemination to the problems of the animal industry, and it was found that the sperm could be kept fertile for several days outside the body by storing it at 40°F (Walton, 1930 ; Hammond, 1930). Walton (1933) adapted and improved apparatus invented in U.S.S.R. for the collection of semen from farm animals, and the first successful long distance transports of fertile semen were made between England and Poland with sheep (Walton & Prawochenski, 1936), and between Holland and England with cattle (Edwards, Walton & Siebenga, 1938). It was also made use of to obtain crosses between breeds in which natural mating was not possible ; reciprocal crosses between the Shire horse and Shetland pony showed that there was a large maternal influence on size (Walton & Hammond, 1938). It was not, however, until the war years when the urgent necessity of mass improvement of our dairy cattle arose that steps were taken to incorporate it into normal breeding practice. A pilot A.I. Centre was established on the University Farm at Cambridge and financed by the Agricultural Improvement Council. The various problems connected with its use in this country were overcome in conjunction with research work at the Animal Research Station (Edwards & Walton, 1938a, 1938b), and after a survey of the practice in U.S.A. by Edwards and Ritchie (1944) it served as a pattern for the development of A.I. stations throughout the country (Hammond, Edwards, Rowson & Walton, 1947). Detailed records were kept at the stations and these led to a number of investigations being made into the problems of fertility. Methods of evaluating the fertility of a sample of semen were investigated (Hancock, Walton, Bishop & Campbell, 1952) and cases of inherited sterility were found (Hancock, 1952). Even with the best samples and techniques or under conditions of normal matings, not more than about a 70% conception rate for first inseminations or matings could be obtained, and research by Laing (1949) showed that this was largely due to the early death of the fertilized ovum ; the causes for this have yet to be discovered, but they form the main problem in the temporary sterility of cattle (Hammond 1948b, 1950c).

Recently, following research into deep freeze methods by Parkes and Polge at the National Institute for Medical Research at Mill Hill, the application of this to bull semen was investigated by Polge and Rowson (1952) at Cambridge, and it was found that by adding glycerine to the semen before deep freezing, bull semen could be kept as fertile as on the day it was collected for, at the time of writing, up to 12 months and how much longer we do not yet know. This, among other things, should allow of a nominated service between any bull and cow in the world wherever they may be situated, and allow of cows being inseminated from bulls which have passed out from this world. It will also allow semen banks to be built up from the very best progeny tested bulls in the slack season of the year to be used during the peak periods and so enable these bulls to produce many more offspring than has been possible in the past.

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AGRICULTURAL ECONOMICS

Changes in the Economic Organization of Agriculture, 1950-51. Pp. 35.

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A comparison is made of the financial results for an identical sample of farms in 1951 and 1950; the data being equally distributed between eight "type of farming" districts in the Eastern Counties.

In both years the profit margin over the whole sample was sufficient to provide interest at 4 per cent on the farm capital, a reasonable wage for the occupier, and a surplus amounting to £5 13s. 9d. per acre in 1951 and £4 8s. 1d. per acre in 1950 to cover the risks involved. An upward movement in profits was common to every district except South Essex, but even here there was a surplus of £2 2s. 3d. per acre in 1951.

Over the whole sample gross income rose by 12 per cent between the two years, and this was mainly contributed by the 1951 barley crop, the price of which was very high compared with that of 1950.

Expenses continued to rise, and on the average gross charges increased by 10 per cent between the two years. The additional outlay on feeding stuffs was particularly pronounced in consequence of the subsidy being abolished.

Crop yields were good in both years, but owing to a very late spring the area of bare fallow in 1951 was higher than usual, and the quantitative output from crops was below that of 1950. In money terms, however, the gross output from both crops and livestock was greater in 1951 than in 1950, and over all the sample the increase amounted to 13 per cent.

An analysis of farm size shows that in 1951 small farms had a heavier investment and employed more labour per acre than large farms. In the upland districts, small farms had larger sales of livestock and livestock products, and relied more heavily on purchases of feeding stuffs. In terms of net output per acre, large farms and small farms from 20 acres upwards had almost the same production per acre. Farm income, i.e. profit as to a tenant farmer, also showed little variation between large and small farms.

In the two fen areas, farms between 20 and 50 acres had a somewhat higher net output and farm income than farms about 50 acres in size. Apart from this group, however, size of holding appears to have little influence on output or profitability per acre.

Report on Farming 1952. Pp. 44.

Fm Econ. Br. Rep. No. 40, 1953. Price 4s. Post free.

The results of the annual survey of 320 farms are reviewed over the period 1944 to 1952. The two outstanding features are the rise in the importance of pigs and poultry, particularly since 1948, and the relative reduction in the importance of cash crops. The latter is not due to a decline in crop production but to the increase in livestock output and the greater amounts of crops fed to livestock. Apart from short term fluctuations, farm income has tended to rise but so also has the cost of living. On average, the real income of farmers in this area has shown little change since 1944.

A more detailed comparison of an identical sample in 1951 and 1952 is made in the next chapter. There was some contrast in weather conditions between the two years. In 1951, spring sowing was delayed by excessive rainfall, whereas in 1952 the spring was dry and early drilling was general. Nevertheless, yields were above average in both years particularly potatoes and root crops.

Farm Income per acre declined on average from £8 16s. 11d. in 1951 to £7 8s. 9d. in 1952, or, if allowance is made for interest on capital and work done by the farmer, from £5 11s. 3d. to £3 10s. 9d. This average, however, conceals a number of local variations. The six upland districts showed a decline in Farm Income from £7 12s. 4d. in 1951 to £5 12s. 8d. in 1952, largely due to the fall in barley prices. But in the fenland districts, where barley is unimportant, farm income increased from £15 16s. 9d. to £17 6s. 7d., due mainly to higher sugar beet yields.

Gross output increased on average by £382 per farm in 1952. In some districts there was little change but in South Essex and the fens, the increase was substantial. An outstanding feature was the increase in pig sales which accounted for half the increased output.

Gross charges rose substantially in all districts, the increase amounting to £594 per farm. Higher prices were mainly responsible and were, in fact, anticipated when the Agricultural Commodity prices were fixed. The composition of gross charges shows little change, labour representing 30 per cent of total outlay and implement costs (including fuel) a further 23 per cent. Rent now accounts for only 5 per cent of total charges.

The remaining section of the report is an advisory supplement and is intended for the use of farmers who wish to test the efficiency of their organisation. Attention is drawn to the effect on farm income of output an acre, labour productivity and efficiency in the use of feeding stuffs.

Profits in Pig Production.

Fm Econ. Br. Fmr's Bull. No. 14. 1953. Price 2s. Post free.

This report presents the results obtained by 47 pig enterprises during the year ended 30th September 1952, in the Eastern Counties. For every £100 of gross output total costs averaged £84. Of this sum £71 was for food both purchased and home-grown; labour accounted for £8 and all other costs for £5. The critical nature of "food cost" was demonstrated by examining the effect on profit of the range around the average of £71.

Breeding sows farrowed on an average every $7\frac{1}{2}$ months and between 7 and 8 pigs were weaned per litter. The small additional amount of food required to raise an extra weaner caused the average cost to fall as the number of pigs weaned per sow rose. The average cost of producing a weaner was £4 10s.

Fattening efficiency was examined according to the average amount of meal equivalent required to produce one pound of liveweight gain. This was 4.77 lb. and it cost 17d. while the average sale price of bacon pigs was 25d. per pound for a pig slightly over 210 lb. liveweight.

From a sample of 23 farms, 70 per cent of the total pigs graded "A" according to back fat measured under the Educational Grading Scheme.

A survey of the market prospects for pigs foreshadowed the opening up of the pork market and the need for increased concentration on efficiency in order to cut costs to meet overseas competition.

A Survey of the Cost of Producing Potatoes in Two Districts of the Eastern Counties, 1951.

Fm Econ. Br. Mimeogr. Rep. No. 45, 1952.

The cost of producing potatoes was surveyed in Holland (Lincs.) and in N.E. Norfolk. The former averaged £87 and the latter £78 per acre, an increase of more than £20 compared with 1948. Labour constituted 32 per cent of this cost and seed 24 per cent. Yields were over 11 tons in both districts, which is exceptional for Norfolk. As a result of these heavy yields, profits were high, averaging £45 per acre.

A Survey of the Cost of Producing Barley in Two Districts of the Eastern Counties, 1951.

Fm Econ. Br. Mimeogr. Rep. No. 46, 1952.

This report surveyed the costs of producing barley in two light land districts of East Anglia—N.W. Norfolk and S. Cambs—in 1951, and compared these costs with those obtained in 1949 in the same districts. Twenty farms were costed in each district. Costs totalled £19 13s. 0d. per acre as compared with £15 19s. 0d. and £13 10s. 6d. per acre in 1949 and 1947 respectively. Manures, net of residues, accounted for 28 per cent of these costs and labour, tractor use and seed approximately 14 per cent each. Profits, averaging over £20 per acre, were abnormally high owing to the exceptional prices following harvest.

Some Economic Considerations of Commercial Egg Production 1951-2.

Fm Econ. Br. Mimeogr. Rep. No. 47, 1953.

This report presents the first year's results of a Poultry Costings Scheme. It compares the profitability of three systems of management and of winter and summer production. The profit in battery production amounted to 8s. 4d. a bird, in deep litter and henyards to 13s. 10d., and on range to 7s. 8d. for the year. The rate of lay was 54 per cent, 49 per cent and 41 per cent respectively. Feedingstuffs which accounted for 65 per cent of the total costs, was the largest single item.

Winter profits and egg yield were highest in batteries, followed by deep litter and henyards then free range. These were 7s. 6d., 6s. 11d. and 1s. 5d. a bird respectively. In summer, range birds made 5s. 10d., deep litter and henyards 4s. 6d. and batteries 9d. a head. Profits from battery birds were low in spite of a high egg yield, whereas the satisfactory return from deep litter and henyard birds was provided by a moderate egg yield produced relatively cheaply. For similar reasons range birds made a good summer profit.

The report suggests that the high cost of purchased meals, coupled with low summer egg prices, accounts for the poor reward to battery birds. Battery producers, however, can improve profits by selling out in spring, when carcass prices are high or, if summer production is continued, they can cheapen the ration by the addition of cereals. The feeding of grain and home-mixed meals substantially lowered feed costs in hen-yard and litter flocks so that a good egg yield was obtained with relatively low costs and production was profitable in both winter and summer.

Other suggestions are made to improve management based on data from the enquiry. The economic advantages of home-rearing are clearly shown (the cost of rearing a pullet was 18s.) as are the profits that accrue if birds are kept after their laying year is completed, and fattened for the Christmas market.

A Survey of the Cost of Producing Sugar Beet in Two Districts of the Eastern Counties, 1952.

Fm Econ. Br. Mimeogr. Rep. No. 48, 1953.

Average costs in West-Central Suffolk (£56 per acre) exceeded substantially those in the Isle of Ely (£49 10s. per acre) mainly owing to more intensive manuring. Yields in Central Suffolk were rather below the average for the last few years and profits were only £9 12s. per acre. In the Isle of Ely, yields were good and profits averaged £29 per acre. An average yield of 9.3 tons was necessary to cover costs in Suffolk and 8.5 tons in the Isle of Ely.

A Record of Agricultural Policy, 1947-1952. Pp. 30.

Fm Econ. Br. Occ. Pap. No. 1, 1952. Price 2s. Post free.

This report summarises the main lines of agricultural policy over the period of the agricultural programme launched in 1947. After a brief survey of the general economic background, the report discusses agricultural legislation, the progress of agricultural output, the annual price reviews, the prices paid for farm produce, agricultural marketing and administration during these years.

STURROCK, F. G. and others.

Farm Economics in U.S.A.

Tech. Assist. Project 57-82-U.K. 1951.

This report summarises the findings of a group of agricultural economists that visited the U.S.A. in 1951.

The first part compares the scope and methods of research in the United States and in Great Britain. While much of the work in the two countries is similar, it is evident that some of the more recent developments in research methods in the U.S. are well worth study in Britain. In particular, the group recommended that more time should be devoted to "free" research and that investigations instigated by the Ministry of Agriculture for use in price-fixing might often be designed to serve better the purposes of research.

The second part compares the university training of agricultural economists in the two countries. In the recommendations, emphasis was laid on the necessity for an adequate training in the fundamental principles of economics.

The third part describes advisory work in farm management in the U.S. Some of the techniques employed—particularly in farm planning—appear to offer scope for development in this country. Attention was also given to the means used in the U.S. to disseminate the results of economic research to the farmer. In view of the recent appointment of liaison officers to the staffs of the Provincial Agricultural Economists in England and Wales this is a matter of interest at the present time.

The appendices describe in more detail the work of the agricultural departments in the universities and land grant colleges visited by individual members of the group.

WHETHAM, E. H.

British Farming, 1939-1949. Pp. viii+172.

Nelson, London, 1953. 12s. 6d.

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CLARKE, G. B. **For Pork or Bacon.** *Fmsr' Wkly.* 29 May, 1953.

POMEROY, R. W. **Cheapest Way to Produce Pork.** *Pig Fmg.* 1953, 1 (2), 16.

AGRICULTURAL ZOOLOGY (including Entomology)

1147* HOWARD, H. W.

Genetics of *Armadillidium vulgare* Latr. III. Dominant and Recessive Genes for Red Body Colour.
J. Genet. 1953, 51, 259-69.

The common colour in the woodlouse, *Armadillidium vulgare*, is black or grey.

Red animals occur at a frequency of from 5 to 8% in many populations.

Red body colour may be due to animals being homozygous or heterozygous for a dominant gene **R**, or to animals being homozygous for a recessive gene **r**.

Animals homozygous for the recessive gene **r** and homozygous or heterozygous for the dominant gene **R** cannot be distinguished.

R and **r** are allelomorphic, the series being **R** (dominant red), + (black), **r** (recessive red).

The black and red pigments are melanins.

It is suggested that in *A. vulgare*, which is a polymorphic species, the nature of the original mutations has determined whether the genes for red body colour should be dominant or recessive.

1175* JONES, F. G. W.

Assessment of the Injury Caused by Seedling Pests of Sugar Beet.

Ann. Appl. Biol. 1953, 40, 606-7.

The seedling pests of beet fall into three groups; those causing loss of stand only, those causing defoliation only, and those causing both defoliation and loss of stand. Injury caused by these pests may be assessed in terms of money, yield, or, occasionally, plant population.

Normally, an excess of 'seed' is sown from which only 25% of potential seedlings appear above ground, 10% having succumbed to fungal disease, 5% to insect attack and 60% to other causes, mainly arising from the physical properties of the soil. The cost of insecticidal seed dressings applied to beet on arable land must be regarded as an insurance against unexpected attacks, especially where reduced seed rates are used to ease the labour problems of singling.

Difficulties have been experienced in trying to assess loss from defoliation and reduced stands by controlling the pests responsible with insecticides. The latter sometimes have undesirable effects that cannot be anticipated and this has led to field experiments in which defoliation and loss of stand have been produced artificially. The results of five such experiments have shown clearly that beet is capable of withstanding up to 75% defoliation at the four and eight leaf stages without suffering more than 10-15% loss of yield. Re-drilling is undesirable so long as even one half of the intended plant population remains, provided the surviving plants are fairly evenly distributed. The use of insecticides against pest attacks of moderate severity is likely to be uneconomical if the cost exceeds £3-£5 per acre.

1167* WINSLOW, R. D.

Hatching Responses in Some *Heterodera* spp.

Ann. Appl. Biol. 1953, **40**, 225-6.

With cysts of beet, cabbage, *Galeopsis*, clover, carrot and hop eelworms, a marked hatch of eggs usually occurred in root leachings from host plants, but not in non-host leachings. In some cases, however, large hatches were induced by the latter. Hatches from pea and oat eelworm cysts were always negligible even in the presence of leachings from host plants. The hatching curves for four species were found to be similar to that described by Fenwick for potato root eelworm. Bio-assay of a mixture of three species showed that quantitative analysis, in terms of 'hatchable' larvae, was practicable.

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DUNNING, R. A. & JONES, F. G. W. **Mangold Fly : More Experiments in Control.** *Brit. Sug. Beet Rev.* 1953, **21**, 111-15, 119.

1150* JONES, F. G. W. & WINSLOW, R. D. **Hatching Responses in Root Eelworm (*Heterodera* spp.).** *Nature, Lond.* 1953, **171**, 478.

AGRICULTURE

BALDWIN, G. G.

Disc Ploughs.

Fm Mech. 1953, **5**, 359-61.

BALDWIN, G. G.

Making High Quality Hay in a Wet Summer.

Yorks Post. 28 Aug., 1953.

MANSFIELD, W. S.

In Praise of Lucerne.

"Times" Agric. Rev. Autumn, 1952, 2-3.

ANIMAL BREEDING AND GENETICS

1146* COCK, A. G.

The Interpretation of Autosexing.

J. Genet. 1953, **51**, 421-33.

Autosexing breeds of fowl may be divided into those which carry the sex-linked gene for barring (*B*), and those which do not. In the former group, the autosexing properties are due to the imperfect dominance of *B*.

A table is presented showing the possible dominance relations between a sex-linked gene which is a hypomorph, hypermorph, antimorph, amorph or neomorph and its wild-type allele, both without dosage compensation, and in conditions of partial and full dosage compensation.

A study of the 'ticks' occurring on birds having various constitutions for the two sex-linked loci *B* and *S* (silver) shows that the ticks are due to somatic elimination of part of an *X*-chromosome. It shows further that *B* is a neomorph (*b* having no action on pigmentation) without dosage compensation, or possibly a hypomorph (*b* having a very weak action in the same direction as *B*) with, at most, a slight degree of dosage compensation. This in itself is sufficient to explain the autosexing properties of barred breeds, without resorting to the improbable assumption that females have a *Y*-chromosome which carries *b*.

Anomalies are pointed out in the dominance relations at several sex-linked loci (*w*, *A*, *B*, *Hw*) of *Drosophila melanogaster*, which are difficult to explain on Muller's theory of dosage compensation.

There is no reason to attribute any autosexing effect to either allele at the silver locus of the fowl. There is some evidence to suggest that the sex hormones, rather than a specific sex-linked gene with a dosage effect similar to that of *B*, are responsible for autosexing in non-barred breeds. On whether the testicular or the ovarian hormone is responsible, the available evidence is conflicting.

1154* DONALD, H. P. & HANCOCK, J. L.

Evidence of Gene-controlled Sterility in Bulls.

J. Agric. Sci. 1953, **43**, 178-81.

A study has been made of the relationships of sterile Friesian bulls manifesting 'knobbed' spermatozoa, and the conclusion drawn that the characteristic defect of the acrosome is due to an autosomal sex-limited recessive gene (*kn*).

1169* HANCOCK, J. L.

Spermatozoa of Sterile Bulls.

J. Exp. Biol. 1953, **30**, 50-6.

Sterility in certain Friesian bulls is associated with a specific morphological abnormality affecting the acrosomes of their spermatozoa.

This abnormality is visible in living spermatozoa and is also visible in fixed spermatozoa when precautions are taken to preserve the morphology of the cell.

If such precautions are not taken, and the spermatozoa are subsequently stained by the nigrosin-eosin method, or with Heidenhain's iron haematoxylin, or when such spermatozoa are examined with the phase-contrast microscope, the abnormality is inconspicuous.

These difficulties do not arise when either the Giemsa stain or indian ink is used.

1177* JOUBERT, D. M.

The Afrikaner Breed in Relation to Cattle Ranching in Tropical and Sub-tropical Regions.
Brit. Agric. Bull. 1953, **6**, 178-185.

The history of the Afrikaner breed of cattle is traced back to pre-Christian times, thus supporting its claim as being a direct descendant of the early African Longhorned Zebu. The breed characteristics are discussed in the light of their significance in hot climates, and the Afrikaner's superiority over exotic types in tropical and sub-tropical regions is proved by quoting the results obtained in experimental studies. Finally the role which the breed at present fulfils in the South African livestock industry is discussed. It is maintained that the Afrikaner has a great future in the beef production programmes of other territories with similar conditions of climate and nutrition.

PEASE, M. S.

Sex-linkage in Poultry Breeding. 4th ed.

Bull. 38. *Minist. Agric. & Fish.* (H.M. Stat. Off., London, 1952. 3s.).

OTHER PAPERS

COCK, A. G. **Autosexing without Barrings.** *Autosex. Annu.* 1953, 6-8.

HAMMOND, J. **An Editorial.** *Zootechnia.* 1952, **1** (5), 2-4.

HAMMOND, J. **Development of Cattle Breeding.** *Brit. Cattle Br. Cl. Dig.* 1952, **8**, 11-21.

HAMMOND, J. **Improvement of Dairy Cattle.** George Scott Robertson Memorial Lecture, Queen's Univ., Belfast. 31 Oct. 1952. Pp. 11, 1s.

PEASE, M. S. **Genetics of Multiple Factor Characters.** *Brit. Cattle Breed. Cl. Dig.* 1953, **9**, 158-75.

1141* PEASE, M. S. **Sex-linkage and Auto-sexing.** *Poult. Wld.* 14 Feb., 1952.

PEASE, M. S. **Simple Mendelism.** *Poult. Guide & Yearb.* 1952, **55**, 22-7.

ANIMAL NUTRITION

1137* EVANS, R. E.

Nutrition of the Bacon Pig. XV. Relative Supplemental Value of the Proteins in Dried Brewers' Yeast and in White-fish Meal.

J. Agric. Sci. 1952, **42**, 422-37.

The object of the present investigation was to compare the supplemental value of the microbial proteins in dried brewers' yeast with the animal proteins in white-fish meal when incorporated in a barley meal-fine bran diet containing a little lucerne meal and suitably adjusted as regards minerals. The investigation was carried out both by the nitrogen-balance method and by the statistically controlled growth method, using the individual-feeding technique. The main problem was to find the minimum percentage of yeast that had to be included in the cereal diet so as to sustain the same rate of growth and economy of food conversion, and to enable retention of nitrogen to take place at the same rate, as is obtained on a standard diet containing 7% of white-fish meal, the total digestible nutrients in all diets being kept approximately constant.

In the first nitrogen-balance trial a comparison was made between the standard diet containing 7% of white-fish meal and a similar basal diet supplemented with 15% of dried brewers' yeast. The percentage crude protein in the yeast diet was 15.39 as compared with 15.12 in the standard treatment, the total digestible crude protein being 12.34 and 12.29, respectively. The supply of total digestible nutrients was almost alike on both treatments.

After about 6 weeks on experiment, the two hogs on the yeast diet became subject to vomiting at rather frequent intervals, although they were always eager for their food and their faeces remained normal. It is unlikely that vomiting was caused by the presence in the yeast of any toxic substance and the possibility that it was due to the presence of live yeast cells is also remote for reasons given. The most likely hypothesis is that it was due to the animals 'bolting' their food with great avidity, since the pigs found the yeast diet to be highly palatable and they always appeared to be hungry.

The two hogs on the yeast diet made average daily live-weight gains of 0.85 and 0.80 lb., the figures over a corresponding period for the hogs on the standard treatment being 0.67 and 0.71 lb. Economy of food conversion was also better on the yeast treatment. The average daily retention of nitrogen was also higher on the yeast treatment the figures being 9.28 and 9.01 g. as compared with 8.07 and 8.90 g. on the standard diet. It is evident therefore that when yeast is incorporated in a cereal diet so as to bring the digestible crude protein content to the same level as in the standard treatment containing white-fish meal, maximum storage of nitrogen takes place, even with young pigs.

In the second nitrogen-balance trial the amount of yeast in the diet was reduced to 12% so as to investigate whether this amount would also support maximum retention of nitrogen and maximum growth. The percentage of digestible crude protein in the diet was 12.56 on the standard treatment and 11.29 on the yeast treatment, the total digestible nutrients being 64.47 and 64.18%, respectively. Over the 63 days that the pigs were in the metabolism crates the two hogs on the standard treatment made slightly higher live-weight gains and retained rather more protein in their tissues, the average retention of nitrogen being 9.43 g. on the standard diet and 8.3 g. on the yeast diet.

It appeared from these results that a cereal diet supplemented with dried brewers' yeast so as to bring the crude protein content to 14.18% (15.95% on the basis of dry matter) does not supply quite enough protein to support maximum retention of nitrogen. In the first experiment, however, when the yeast diet contained 15.39% of crude protein (17.37% on the basis of dry matter) the results were fully equal to the standard treatment containing 15.12% of crude protein (17.21% on the basis of dry matter). These conclusions were tested further by means of a growth trial with ten individually-fed pigs on each treatment.

In the growth trial the ten pigs on treatment A received a supplement of 9% of dried brewers' yeast, those on treatment B were on the standard diet containing 7% of white-fish meal and those on treatment C received a supplement of 12% yeast. The percentage of crude protein on the mean moisture basis was 14.62 in treatment A, 16.15 in treatment B and 15.4% in treatment C.

It was concluded from the results of this growth trial that when approximately one-third of the total crude protein in the diet comes from either dried brewers' yeast or white-fish meal, complete supplementation of the proteins in the basal diet of barley meal and fine bran occurs, so as to enable maximum retention of nitrogen or maximum growth to take place without wastage of amino-acids. The results for treatment A suggest that the proteins in yeast may even be superior in supplemental value to the proteins in white-fish meal.

The deductions made from both methods of experimentation are therefore in close agreement and the results show that a basal diet of 2 parts of barley meal and 1 part of fine bran with a little lucerne meal and minerals when supplemented with dried brewers' yeast so as to bring the crude protein content of the mixture to about 15.5% enables the young pig to store the maximum amount of protein in its tissues and to grow at a maximum rate in conformity with the net energy content of the diet. The distribution of essential amino-acids in the proteins of yeast and in the proteins of white-fish meal, when based on equal weight of crude protein, is not significantly different, any differences being slightly in favour of the yeast proteins.

A comparison is also made between the results obtained with dried brewers' yeast and those obtained with extracted decorticated ground-nut meal used in previous trials.

1138* EVANS, R. E.

Nutrition of the Bacon Pig. XVI. Relative Supplemental Value of the Proteins in Extracted Soya-bean Meal and in White-fish Meal.

J. Agric. Sci. 1952, **42**, 438-53.

The investigation showed that a diet composed of 2 parts of barley meal, 1 part of fine bran and a small allowance of lucerne meal and minerals, when supplemented with extracted soya-bean meal so as to bring the crude protein content of the diet to about 16%, will promote the same rate of growth or nitrogen retention in young pigs, as is obtained with a standard-diet containing roughly the same proportions of basal foods in conjunction with 7% of white-fish meal. On the dry-matter basis the soya-bean diet contained approximately 18.6% of crude protein and the white-fish meal diet 17.4%.

The data in Table 24 provide evidence for concluding that the proteins in extracted soya-bean meal are inferior to the proteins in white-fish meal for supplementing the proteins in barley meal and fine bran. Thus, in order to secure equal rates of live-weight increase in young pigs, the soya-bean meal diet had to supply about 12.9% of digestible protein as compared with about 12.3% in the case of the fish-meal diet. Further, the soya-bean proteins had to form about 39% of the total crude protein in the diet, whereas when white-fish meal was used as the protein supplement, equally good results were obtained when the fish meal proteins formed only 28% of the total crude protein.

In our previous investigation of the supplemental value of the proteins in extracted-decorticated ground-nut meal (Woodman & Evans, 1951) it was found, using the same basal diet, that in order to get equality of growth and nitrogen retention, it was necessary to include as much as 20% of extracted decorticated ground-nut meal in the diet. The crude-protein content of such a diet is about 18.5% on the air-dry basis (21.2% on the basis of dry matter). This compares with about 16% of crude protein (18.6% on the basis of dry matter) if the diet is supplemented with extracted soya-bean meal. Moreover, as much as 54% of the total crude protein in the ground-nut diet had to be provided in the form of ground-nut protein. It is evident therefore that although the supplemental value of the proteins in extracted soya-bean meal is inferior to that of the proteins in white-fish meal it is distinctly superior to the proteins in extracted-decorticated ground-nut meal, when fed in conjunction with the basal diet used in both investigations.

Finally, it is interesting to note that as good results, from the standpoint of live-weight gain, economy of food conversion and nitrogen retention in young pigs, were obtained with the vegetable protein concentrates (extracted soya-bean meal and extracted-decorticated ground-nut meal) as with the animal protein concentrate white-fish meal, when the level of protein fed was adequate. This seems to cast doubt on the need for 'animal protein factors' in the diet of bacon pigs. Further experiments are, however, in progress to obtain more information on this point and any definite conclusion will have to await the results of these investigations.

1162* HALNAN, E. T.

Progrès Réalisés Récemment en Matière d'Alimentation de la Volaille.

Bull. Tech. d'Inform., Paris. 1953 (80), 383-6.

In this paper, given at an F.A.O. meeting held in Paris in March, 1953, the progress which has taken place in poultry nutrition research since 1949 is reviewed. The animal protein factor, so important in the effective utilisation of vegetable proteins for growth of chicks has been shown to be akin to vitamin B₁₂. This vitamin stimulates the growth of chicks reared on vegetable protein diets, is important as a hatchability factor, but does not stimulate egg production. Antibiotics have also been shown to stimulate chick growth, except in a minority of cases. This stimulation of growth is most marked in the early stages of the chick's life and is more marked in the case of birds on vegetable protein diets, but the effect gradually declines as the chick reaches maturity. The early stimulation of growth has no effect on the mature weight of the pullet nor on subsequent egg production. The growth response appears to be related to the extent to which the chicks are subject to recognisable and non-recognisable infections of the gut, such infections depressing the growth rate which is restored to normal by the administration of antibiotics. Their use would appear to be justified as an aid to stimulating the growth of chicks and turkey poults intended for meat production but there would appear to be no nutritional advantage in including antibiotics in layers and breeders diets. The discovery that growth promoting factors develop in the controlled fermentation of poultry litter has resulted in the commercial adoption of a deep litter system of poultry management.

HAMMOND, J.

Education in Animal Nutrition.

Proc. Nutr. Soc. 1953, 12, 178-81.

A short account of the organization and ways in which instruction is given at different levels, University, Farm Institute, and Advisory Service, in Great Britain, and how in order to meet the ever-changing needs it is based on well organized research dealing with current problems.

OTHER PAPERS

BROOKES, A. J. **Rearing Calves.** *Cattle Br.* 1952(2), 10-20.

ANIMAL PHYSIOLOGY

1164* ADAMS, C. E.

Inhibition of Superovulation in the Rabbit.

Nature, Lond. 1953, 172, 82.

The horse pituitary extract AP 118 B induces superovulation in albino does at 12 weeks of age, provided the animals are fed at a high level from birth. Treatment consists of six subcutaneous injections of this pituitary extract at 12 hr. intervals, followed by an intravenous injection of 25 i.u. Prolan 12 hr. later. When this treatment was repeated in the same does at 28 day intervals, in 95% of the experiments the ovarian response was poor and ovulation did not occur. Ovulation did occur at sexual maturity, but only the normal number of ova was shed.

Experiments were then performed to determine whether citrated plasma from an AP 118 B treated doe would inhibit ovarian response in a previously untreated doe when the latter was afterwards treated with AP 118 B. The results suggest that the plasma has this inhibiting power.

It is concluded that the decreased ovarian activity associated with repeated treatment with AP 118 B is attributable to antibody formation.

1153* EDGAR, D. G.

Chemical Assay of Progesterone.

Biochem. J. 1953, 54, 50-55.

The development of a chemical technique for the detection and determination of progesterone in biological material is described. It is based on the extraction of the hormone and its partition between organic solvents, its final separation by chromatographic partition on filter paper and its subsequent estimation by ultraviolet absorption spectroscopy.

Work on the chromatography of steroids has resulted in the development of a reversed phase system capable of separating progesterone from impurities, which is also of value in establishing the identity of substances isolated from biological material.

1145* EDGAR, D. G.

Vaginal Eversion in the Pregnant Ewe.

Vet. Rec. 1952, 64, 852-8.

The outbreaks of vaginal eversion recorded in several flocks of ewes, and the prevalence of the condition in New Zealand in some years suggest that environmental factors favour the occurrence of the disease. From a study of the circumstances of these outbreaks it is difficult to see what are the particular factors concerned.

The onset of uterine contractions in one ewe has been shown to be the immediate cause of vaginal eversion, although it is equally clear that this was not the only cause. A predisposition to the condition is indicated, as other ewes subjected to similar treatment did not develop it, and there is some evidence that a hormonal imbalance may be involved.

Such a predisposition may well be inherited (vaginal eversion occurs regularly in one closely bred flock), and there is evidence that it is inherited in cattle.

Although further investigation is necessary to confirm this heritability, the practice of culling ewes which have developed vaginal eversion appears a sound one. It should be extended to the lambs from such ewes, which should be marked at birth and not retained for breeding.

1165* HAMMOND, J.

Applications of 'Animal Physiology' to Agriculture.

Adv. Sci., 1953, **10** (38), 237-42.

'Animal physiology' as a basal science for animal production has to co-ordinate the results of pure scientific research in anatomy, zoology, genetics, physiology, endocrinology, and biochemistry, and determine the interactions between these so that control over animal production can be obtained. In doing this it is often found that there are large gaps in knowledge between the pure sciences, for example between anatomy and physiology in the methods of control of the conformation of animals, which need to be filled in by the applied scientist. Examples are given of the ways in which animal physiology can be applied to problems of animal production. Special reference is made to problems of fertility, milk production, meat production, selective breeding, climatic influences, wool production, and animal behaviour in which active research is now in progress.

HAMMOND, J.

Reproduction in the Ewe.

Trab. II Congr. Int. Vet. Zoot. Madrid, 1951 (1953).

An account is given of recent experiments at the Animal Research Station, University of Cambridge.

The breeding season is controlled by the length of darkness and daylight hours. The length of the breeding season in different breeds is related to the latitude and altitude of their origin. The breeding season is shorter in lambs than in adult ewes. Subcutaneous injection of Pregnant Mare Serum Hormone (P.M.S.) will cause ovulation during the non-breeding season, but so far it has not been possible to obtain heat and pregnancy regularly by this means. Small-scale experiments have shown that during the breeding season the lambing percentage can be increased by injections of 450 i.u. P.M.S. at the 12th day of the oestrous cycle.

The weight of the lamb at birth and the amount of milk given by the ewe after parturition can be controlled by the plane of nutrition of the ewe during the last two months of pregnancy.

Barren ewes may be made to secrete milk in considerable quantities by the subcutaneous implantation of tablets of stilboestrol.

1155* POMEROY, R.

Studies on Piglet Mortality. I. Effect of Low Temperature and Low Plane of Nutrition on the Rectal Temperature of the Young Pig.

J. Agric. Sci. 1953, **43**, 182-91.

The rectal temperature of piglets was determined (a) at intervals from birth up to 18 days, (b) at the same time daily until the piglets appeared to be fully thermoregulated.

The rectal temperature of a vigorous piglet during parturition may be as high as 104-105°F.

During the first few minutes after birth the temperature falls to about 100°F., partly as a result of the lower temperature of the external environment and partly as a result of the rapid evaporation of amniotic fluid with which the young pig is covered. The fall in temperature is greater with lighter pigs than with heavier pigs.

The temperature falls until the young pig finds its way round to the teats and starts to suckle. This struggle and activity of suckling together with the warmth in the sow's nest causes a temporary rise in temperature. During the first rest the temperature falls again to about 100°F., but vigorous pigs have a normal temperature within 12 hr.

Piglets deprived of milk after 5 hr. and 16 hr. suckling experienced a more or less steady fall in temperature to about 98°F in 2-3 days, when the pigs were comatose and were killed. In the case of a pig which had suckled for 7-8 days the temperature remained more or less normal for 2 days and then declined to 95°F, during 5-6 days. The length of survival depends largely on the initial weight, i.e. on the reserves accumulated during the suckling period, and possibly on the thickness of the insulating layer of subcutaneous fat.

Lactation failure in the sow, causing the young pigs to go back in condition, results in a fall in body temperature of the piglets. The extent of the fall depends on the degree of failure and the external temperature. But if the body temperature falls to 95°F. the pigs become first lethargic and apathetic, then comatose and eventually die. Such pigs may be revived from coma temporarily by warmth and by glucose therapy, but they seldom survive.

Experimental chilling for 2 hr. at 35-40°F. caused a fall in temperature of a newly born pig to below 90°F. Although it became comatose it revived after a few hours and appeared none the worse. It survived and its subsequent growth rate was as good as that of its litter mates. Under the same conditions chilling

after 12 hr. or longer causes very little fall in temperature of recently suckled pigs, but may cause a fall of 5–8°F. in suckled pigs at 48 hr.

Chilling young pigs on high and low planes of nutrition had little differential effect. The initial and final temperatures of the low-plane pigs were lower than the high-plane pigs, but the relative fall in both cases was much the same.

1149* WALTON, A.

Flow Orientation as a Possible Explanation of 'Wave-Motion' and 'Rheotaxis' of Spermatozoa.
J. Exp. Biol. 1952, **29**, 520–31.

Flow orientation of spermatozoa in dense suspensions has been demonstrated by optical and electrical methods.

Relaxation time, i.e. the time required for a suspension of elongated cells, which have been orientated by flow, to retain a certain degree of random distribution when flow ceases, has been shown to be closely and inversely related to motility, as measured by impedance change frequency in the suspension.

Flow orientation may provide a physical explanation of 'wave-motion' and 'rheotaxis' of spermatozoa.

Wave-motion occurs in a suspension of elongate cells which possess progressive motility in the direction of the long axis of the cell. Orientation of the cells may be brought about by 'short-range order' or flow. Dis-orientation may be brought about by streams of orientated cells moving in random directions. In the suspension as a whole an equilibrium will be reached such that the forces tending towards orientation (short-range order or flow) are balanced by forces tending towards dis-orientation (streaming). In small regions, however, statistical variation in the direction and velocity of the streams set by up sperm movements will produce local disturbance of the equilibrium and turbulence or wave-motion will result.

ANIMAL PRODUCTION

1140* BROCK, H. & ROWSON, L. E. A.

Production of Viable Bovine Ova.
J. Agric. Sci. 1952, **42**, 479–82.

A comparison has been made between the effect of various forms of P.M.S. on the cow's ovaries by giving 3000 i.u. of: (a) processed P.M.S., (b) fresh whole P.M.S., (c) freeze-dried P.M.S.; the average follicle numbers produced being 13.9, 20.1, and 14.5 respectively.

The effect of the time interval between the injection of P.M.S. and L.H. on oestrus has been studied in the presence and absence of a corpus luteum. The time factor was found to have a direct relationship to the ovulation percentage (in the absence of the corpus luteum 11.6% at 2 days to 86.2% at 7 days interval), but that there were limits beyond which degeneration of the ova occurred. It is believed that the best interval to aim at is 5 days.

Evidence of the susceptibility of the uterus to infection when under the influence of a corpus luteum and its resistance to infection when under oestrogens has been shown.

The culture of eggs in serum and in follicular fluid was attempted with very limited success.

1161* CAMPBELL, R. C., HANCOCK, J. L. & Lord ROTHSCHILD

Counting Live and Dead Bull Spermatozoa.
J. Exp. Biol. 1953, **30**, 44–9.

An investigation has been made into the accuracy of estimates of the proportions of dead spermatozoa in diluted and undiluted bull semen, using the nigrosin-eosin live-dead staining technique.

Two operators counted 24,673 spermatozoa, in lots of approximately 200, on smears derived from a number of subsamples taken from the same ejaculate.

The variations between different counts made on one smear were consistent with random sampling from a binomial population; the same applied to variations between slides made from one subsample; the variation between subsamples were, however, larger than would have been expected on the basis of random sampling.

Undiluted semen and semen diluted 1/4 with Ringer-phosphate-fructose solution had the same mean percentage dead and precision of estimation.

Tables are given showing how the precision of an estimate of the proportion of dead spermatozoa in a sample varies according to the percentage of dead spermatozoa, the total number of spermatozoa counted and according to the number of subsamples taken from the original ejaculate, each subsample being used for making counts.

1172* CAMPBELL, R. C.

The Effect of Semen Age on Conception Rate.
J. Agric. Sci. 1953, **43**, 256–9.

The relationship of semen age to conception rate (c.r.) was studied at two artificial insemination centres and a subcentre of one of these. A total of 50,213 first inseminations were included in the data.

At one main centre, A, the decrease of conception rate was 4% for each day of semen age; at the other main centre C, the decrease was about 2%. This difference between centres was significant and showed that the rate of decrease is not the same in all semen but can be affected by external conditions.

At the beginning and end of the test period there were differences between A and its subcentre B in the first day c.r.'s and in the rates of decrease, even though the same semen was used at both centres. These differences could not be detected in records giving mean c.r.'s only.

In the middle of the test period the mean c.r.'s at A and B differed by 11.2%; this difference was due to a combination of a lower first day c.r. and a more rapid decrease at B.

The residual mean squares in the analyses were larger than expectation, so that there was a loss of sensitivity in the tests made. A probable contributory cause of this was the grouping of the results by months rather than keeping collections separate.

The rate of decrease should not be used for comparing centres until the various factors affecting it, e.g. breed differences, are more fully understood. Further investigations should not be limited to one centre.

1166* HAMMOND, J.

Contributions of Artificial Insemination and Milk Recording to the Dairy Industry.

J. Soc. Dairy Tech. 1953, **6**, 15–21.

Some of the ways in which milk recording can help to increase milk production are outlined. The finding of Progeny tested bulls has now been well organised by the publication of lists by National Milk Records. This will enable breeders to make better selection of young bulls by obtaining sons of progeny tested bulls out of high lifetime production cows. This list also indicates to A.I. Centres where they can obtain good bulls. The new method of deep freeze semen will enable better use to be made of the best bulls, especially where calving is seasonal. The method of insemination of one third of the worst cows in the herd by a colour-marking beef bull, not only improves the natural dairy herd by preventing the worst milking animals from producing dairy offspring, but also supplies a valuable by-product—calves suitable for rearing for beef purposes.

1156* LUTWAK-MANN, C. & ROWSON, L. E. A.

Chemical Composition of the Pre-Sperm Fraction of Bull Ejaculate obtained by Electrical Stimulation.

J. Agric. Sci. 1953, **43**, 131–5.

Semen was collected from bulls by means of the electro-ejaculation method developed by Thibault *et al* (1948).†

A copious sperm-free fraction of the ejaculate, produced in the early phase of stimulation, was examined for its chemical composition.

This secretion was found to have a low protein content, but its chloride concentration was higher than in the sperm-containing fractions of the ejaculate. Fructose and citric acid occurred in very low concentrations, and 5-nucleotidase was absent in the pre-sperm secretion. This indicates clearly that the secretion does not originate either in the seminal vesicles or in the ampullar glands; it is probable that it represents a discharge from the urethral glands.

The effect of the pre-sperm ejaculate fraction upon bull sperm fructolysis and motility was examined; both were unaffected by a considerable excess of this secretion.

The chemical composition of the pre-sperm secretion makes it unlikely that under physiological conditions it could play a role in the nutrition of the spermatozoa; presumably, its chief function is the clearing of the urethral passage prior to the descent of the semen propher.

1178* MANN, T. & WALTON, A.

The Effect of Under-feeding on the Genital Functions of a Bull.

J. Agric. Sci. 1953, **43**, 343–7.

A study was made of the effect of under-feeding on the genital functions in the bull. Regular weekly collections of semen were made during (1) a 5-week pre-experimental period of normal feeding, (2) a 23-week experimental period of under-feeding, and (3) a 25-week post-experimental period of recovery.

Although the food intake was reduced to such an extent that the bull began to lose weight at a rate of 6.5 kg. (1 stone) per week, the volume and density of semen and the motility and morphology of the spermatozoa were not significantly changed.

In contrast to the testes, the secretory function of the male accessory glands was markedly affected by under-feeding. The concentration of fructose and citric acid in semen decreased to about 30% and 60% respectively of the original levels. During the recovery period the values for fructose and citric acid gradually returned to normal.

1157* ROWSON, L. E. A., LAMMING, G. E. & FRY, R. M.

Relationship between Ovarian Hormones and Uterine Infection.

Vet. Rec. 1953, **65**, 335–40.

The bovine uterus during oestrus appears remarkably resistant to infection introduced either as infected semen or as a culture of *C. pyogenes*. During the luteal phase the bovine uterus appears equally susceptible to such infection and pyometritis frequently results.

Experiments on ovariectomised cows show that exogenous progesterone promotes conditions suitable to the growth of certain bacteria, while exogenous oestrogen will render the bovine uterus equally resistant to infection.

† *C. R. Acad. Sci., Paris*. **226**, 2006.

The addition to semen of penicillin, streptomycin and sulphanilamide at the usual rates used in artificial insemination practice will prevent the development of bacteria, after insemination during the luteal phase. Preliminary results indicate that the use of Lugol's solution during the luteal phase can produce a sterile pyometritis.

Uterine infections may be established and controlled by varying the ovarian hormone levels. They can be produced in the presence of a corpus luteum and suppressed either, on the one hand, by its removal, or on the other, by injecting high doses of oestrogen.

These results may indicate the possibilities of using exogenous oestrogens to treat puerperal sepsis in humans, or *V. fetus* and trichomonad infections in the bull. They may explain why the cow recovers spontaneously from trichomonad and *V. fetus* infections after several heat periods without re-infective coitus, whereas the bull does not recover spontaneously since testosterone has a systemic effect similar to that of progesterone in the cow.

OTHER PAPERS

HAMMOND, J. **We Want Danish Methods—but not Danish Pigs.** *Fmr's Why*. 1952, **37** (16), 41.

1163* LAMMING, G. E. & ROWSON, L. E. A. **Ovarian Hormones and Uterine Infection in Cattle.** *Proc. R. Soc. Med.* 1953, **46**, 387–92.

1152* ROWSON, L. E. A. LAMMING, G. E. & FRY, R. M. **Influence of Ovarian Hormones on Uterine Infection.** *Nature, Lond.* 1953, **171**, 749–50.

PLANT BREEDING AND GENETICS

New and Promising Varieties Recently described in the Literature. 8th Issue. Pp. 51.

Commonw. Bur. Pl. Breed. & Genet., Cambridge, 1953. 6s.

This new issue contains a list of all the most interesting varieties of crop plants, fruits, nuts and vegetables that have been described in the technical literature during the last four years. Details are given of the main characteristics of the varieties listed, their name and origin, and sources from which further information and samples of seed can be obtained.

1159* BELL, G. D. H. & SACHS, L.

Investigations in the Triticinae. II.

J. Agric. Sci. 1953, **43**, 105–15.

Chromosome pairing has been studied in twenty-two different sterile F_1 hybrids involving the genera *Aegilops*, *Agropyron* and *Triticum*, together with their colchicine derived amphi-diploids having chromosome numbers of $2n=42$, 56 and 70. Cytological evidence has been correlated with male and female fertility, while chromosome pairing in the parents has been studied in relation to their amphidiploids.

Some of the sterile F_1 hybrids showed little or no pairing, while in others the pairing was appreciable. There was an association of the amount of pairing with the parental combinations used in the production of the hybrids in that the interspecific hybrids were characterized by a relatively high degree of pairing, particularly those with 28 chromosomes, while the intergeneric hybrids either lacked pairing or showed a low incidence.

In the A^1 amphidiploid generation, chromosome pairing was in all cases high, and in some cases almost complete. In all cases multivalent formation in the amphidiploid was lower than bivalent formation in its undoubted F_1 hybrid. Different amphidiploids showed various degrees of differential affinity. Univalent formation occurred in some amphidiploids, while bivalent formation in some was increased by a loss of chromosomes.

In all cases there was a reduction in chiasmata per nucleus and chiasmata per bivalent in the amphidiploid compared with its parent species. Reduction values were not directly associated with any increase in chromosome number of the amphidiploid, nor with the presence of multivalents.

No confirmation could be obtained of the view that multivalent formation in amphidiploids is a more generally sensitive index of chromosome homology than bivalent formation in the undoubted F_1 hybrid. The absence of multivalents in an amphidiploid does not disprove the existence of structural chromosome homologies between the two parents.

In general, there was no direct relationship between multivalent formation and fertility in these amphidiploids, while high fertility was observed in certain amphidiploids with univalents.

The high degree of fertility found in amphidiploids with multivalents, and in some amphidiploids with univalents, may be explained by the survival of gametes despite a certain reduction in the full chromosome complement. This view is supported by evidence on the fertility of monosomics and the survival of chromosome deficient gametes.

A newly derived amphidiploid may show a higher survival ability for chromosome-deficient gametes than does an older, naturally occurring polyploid species. It would appear, therefore, that this capacity for high survival may be lost in later amphidiploid generations. A whole range of fertile types might arise in amphidiploids producing multivalents derived from species which show considerable bivalent formation in their undoubted F_1 hybrids.

1151* CAMPBELL, G. K. G.

Selection of Sugar Beet for Resistance to Bolting.

C.R. XVI Assembl. Inst. Intern. Rech. Betterave. 1953, Pp. 5.

At the Plant Breeding Institute sugar beet seedlings are exposed to a prolonged photoperiod during the winter, thereby receiving a controllable stimulus to bolt; during the summer, physiological types more or less resistant to bolting can easily be separated. This photoperiodic stimulus may be modified to test resistance to bolting independently of spring weather conditions.

1160* HOWARD, H. W.

Autotetraploid Green Watercress.

J. Hort. Sci. 1952, **27**, 273-7.

A tetraploid green watercress with a chromosome number of 64 was made by colchicine treatment of a commercial stock of green cress which has a chromosome number of 32. This doubling of chromosome number produces a plant with broader and thicker leaflets which, it is suggested, is a valuable feature for a salad plant. It is not, however, yet known how the new type with the doubled chromosome number will compare for yield with the original stock. Other possibilities in watercress breeding by the use of colchicine for chromosome doubling are discussed.

HOWARD, H. W.

Crops and Plant Breeding.

J. R. Agric. Soc. 1952, **113**, 133-44.

The headings in this annual review article were:—Cereals, popularity of varieties, seed rates; Wheat, descriptions of varieties, resistance to yellow rust; Oats, descriptions of varieties, resistance to yellow rust; Barley, description of a variety, breeding problems; Linseed, identification of varieties, yield trials; Peas; Beans, field investigations, natural cross-breeding, resistance to black fly; Sugar Beet, diseases, processed seed, triploid sugar beet seed; Fodder Beet; Herbage Plants, palatability, lucerne, commercial samples of strains; Brassica Crops, oil seeds, marrow-stem kale, vegetative propagation; and Chemical Weed Control, selective weed control in pastures, selective weed control in peas, use of sodium chlorate.

1173* HOWARD, H. W.

Physiological Races of *Phytophthora infestans*: A Comparison of the Differential Hosts at the Plant Breeding Institute, Cambridge, with those of the Scottish Society for Research in Plant Breeding.

Ann. Appl. Biol. 1953, **40**, 584-93.

At the Plant Breeding Institute, Cambridge, there have been recognized three physiological races of blight (*Phytophthora infestans*), *A*, *B*, and *C*; and at the Scottish Society for Research in Plant Breeding, Edinburgh, there have been used five races, *A*, *B*¹, *B*², *C* and *D*, obtained in the British Isles.

It is shown that the two Cambridge types of differential hosts, *AbC* and *ABc* (where *A*=resistant to race *A*, *a*=susceptible to race *A*, etc.), are *Ab*¹*b*²*CD* and *AB*¹*B*²*cD* respectively on the Scottish scheme, and that the Cambridge races, *A*, *B* and *C* correspond to the Scottish races *A*, *B*¹ and *C* respectively.

A number of blight isolates were tested on both the Cambridge and Scottish differential hosts. Isolates of race types *A*, *B*¹, *B*², *C* and *D* were found.

The identification and origin of physiological races of blight and the breeding of blight resistant potatoes are discussed.

LUPTON, F. G. H.

Mummy Wheats.

Agriculture: J. Minist. Agric. 1953, **56**, 286-88.

The results of trials carried out at the Cambridge Plant Breeding Institute suggest that any extravagant claims about the yields obtained from "mummy wheats" should be regarded with considerable scepticism. There is certainly no truth in the belief that these wheats survived from the times of the Pharaohs.

SACHS, L.

Chromosome Behaviour in Species Hybrids with *Triticum timopheevi*.

Hered. 1953, **7**, 49-58.

Two types of *T. dococcoides* (a) and (b) have been found to differ in their chromosome structure. These types show that all the cytological differentiation among the 4 \times species of *Triticum* can be found within the species *dicoccoides*.

All the cytologically different 4 \times species of *Triticum* could thus have been derived from an original 28 chromosome prototype.

Tetraploid species hybrids with *T. timopheevi* show sterility presumably owing to recombination between chromosomes containing non-homologous segments.

Metaphase chromosome pairing in hybrids is not sufficient to assign distinct genome formulae for the properties of different chromosome sets in various species.

SACHS, L.

The Occurrence of Hybrid Semi-lethals and the Cytology of *Triticum macha* and *Triticum vavilovi*.
J. Agric. Sci. 1953, **43**, 204-13.

A semi-lethal gene combination has been found in hexaploid species hybrids involving some strains of *Triticum macha*, but not in comparable hybrids involving other strains of *T. macha*. The production of these semi-lethal hybrids can be explained by the interaction of two genes designated as m^a and m^b .

The gene m^a is carried in some strains of *T. macha*. The gene m^b is carried in the third chromosome set of all other hexaploid species of *Triticum*, in *Aegilops squarrosa* and in *Aeg. cylindrica*.

The semi-lethal gene combination has been found between species which would otherwise produce fertile hybrids and between species which would otherwise produce sterile hybrids. The semi-lethal gene combination occurs between species which do not overlap geographically.

The distribution of the genes m^a and m^b shows that the gene m^a originated in *T. macha*, and that the gene m^b originated in *Aeg. squarrosa* and was introduced from there, during the course of evolution, into the hexaploid species of *Triticum* (probably excluding *T. macha*) and into *Aeg. cylindrica*.

Meiosis in semi-lethal plants was compared to meiosis in normal plants. But the semi-lethal plants showed a reduction in fertility, probably as a result of their poor vegetative growth.

The chromosomes of *T. macha* and *T. vavilovi* have been no more structurally differentiated than the chromosomes of the other hexaploid species of *Triticum*.

The present study has confirmed that the third chromosome set of the genus *Triticum* has been phylogenetically derived from *Aeg. squarrosa*.

SWAMINATHAN, M. S.

Polyploidy and Plant Breeding.

New Biol. 1952, **13**, 30-48.

Examples of polyploids of crop plants produced by colchicine treatment are mentioned and some of the potentialities and limitations of improving plants by this means are discussed. It is pointed out that breeding with induced polyploids is not an act but a process, a long period of intensive breeding and selection of the resulting plants being required before they can be introduced for general cultivation.

THOMAS, M.

Back Crossing. The Theory and Practice of the Backcross Method in the Breeding of Some Non-Cereal Crops. Pp. vi+136.

Tech. Commun. No. 16. Commonw. Bur. Pl. Breed. & Genet., Cambridge, 1952. 15s.

Back-crossing is now firmly established as one of the most valuable techniques at the service of the crop breeder, and the method is particularly important in exploiting the genetic resources of wild material. Since Harlan and Pope first drew attention to the value of the technique in cereal breeding, back-crossing has been successfully applied not only to cereals, but also to several other crops, especially in the last decade or so. The bulletin concentrates upon four of these other crops. After a short introductory chapter on the theory and history of the technique, Chapter II surveys in considerable detail the highly important work carried out on back-crossing in cotton in the Sudan, United States and other countries, an account being given of back-crossing for good fibre properties, resistance to blackarm, *Fusarium* and *Verticillium* wilts, resistance to jassid and other pests, deciduous bractlets and suitability for mechanical harvesting. In Chapter III a survey is presented of the use of the method in tobacco breeding for resistance to mosaic, wildfire, and other diseases, resistance to nematode, earliness, low nicotine content, smoking quality, yellow leaf colour, and petiolate leaves. Chapter IV surveys back-crossing in the tomato, its chief topic being investigations on *Lycopersicon pimpinellifolium* and other species for the transference of disease and pest resistance and high vitamin C content. The concluding chapter reviews the results of back-crossing with *Solanum* spp. and Müller's W races to introduce disease resistance and other characters into the cultivated potato. A conveniently separate bibliography completes each chapter.

OTHER PAPERS

BELL, G. D. H. **Application of Genetics and other Sciences to the Breeding of Agricultural Plants.** *Biol. & Hum. Aff.* 1953, **18**, 115-21.

BELL, G. D. H. **History of Cereal Cultivation. Pt. I.** *Ass. Agric. Rev.* 1953(20), 16-24.

1176* **Report from the Commonwealth Bureau of Plant Breeding and Genetics, Cambridge.** *Brit. Agric. Bull.* 1953, **6**, 66-9.

1170* WHITEHOUSE, R. N. H. **Breeding for Yield in the Cereals.** *Heredity.* 1953, **7**, 146-7.

SOIL SCIENCE

1142* CHILDS, E. C.

Measurement of the Hydraulic Permeability of Saturated Soil *in situ*. I. Principles of a Proposed Method.

Proc. Roy. Soc. 'A'. 1952, **215**, 525-35.

A steady-state method is described for measuring the permeability of soil *in situ*; it is applicable only to saturated soil below the water table. A pair of small wells, in one of which is placed a pump, forms a water circulating system. The pump depresses the level in one well and the pumped water, being passed through a flowmeter and emptied back into the second well, maintains a level in the latter higher than the static equilibrium level. The difference of levels in the wells is related to the rate of flow of water and to the soil permeability.

In anisotropic media the method gives apparent horizontal permeability. The use of two pairs of wells, the planes containing the axes of each pair being suitably oriented, enable us to determine the permeabilities in the directions of the horizontal axes of anisotropy. Combining our method with Kirkham's, which provides an estimate of apparent permeability which is dependent upon both horizontal and vertical permeabilities, we are able to calculate the axial permeabilities of triaxially anisotropic material.

1144* CHILDS, E. C. & EDWARDS, D. H.

Measurement of the Hydraulic Permeability of Saturated Soil *in situ*. II.

Proc. Roy. Soc. 'A'. 1953, **216**, 72-89.

After a brief description of a new sand-tank laboratory and equipment for studying problems of the flow of fluids in porous materials, the remainder of the paper is devoted to an account of the application of a part of this equipment to a study of the flow of water between a pair of wells, such as is required for the determination of the permeability of the sand by the method described in Part I. The potential distribution about the wells is found to conform sufficiently well with theory to justify the application of the analysis of Part I, the interference due to the confining walls being satisfactorily negligible.

The perturbation of the water table inseparable from the imposition of a potential difference between the wells is found not to invalidate the results based on an assumption of two-dimensional flow, while the corrections on account of the presence of a capillary fringe and a surface of seepage are satisfactorily made by adding to the measured depth of water in the well an increment equal to about half the thickness of the capillary fringe. The end correction for non-penetrating wells is also sufficiently well made by an addition to the measured depth of water; the magnitude of the correction is given for isotropic media for a well system of the dimensions used here, and the method of applying it to anisotropic media is indicated.

The two-well method is used to estimate the permeability of the sand, which is then discussed in relation to the pore-size distribution. The elucidation of the permeability profile in a succession of strata is then discussed. Finally, techniques suited to work in the field are described, and a few preliminary field results are quoted.

CHILDS, E. C.

A New Laboratory for the Study of the Flow of Fluids in Porous Beds.

Proc. Instn Civ. Engrs. 1953, 134-41.

Insight into problems relating to the flow of fluids in porous materials may be gained by rigid mathematical analysis and by various methods of successive approximation, but when the limits of such approaches are reached, further progress can be made only by model or full-scale study of porous materials themselves. The paper describes an installation for such study, comprising a large sand-tank with provision for controlled artificial rainfall and for drainage. The equipment includes a reservoir divided into sections to form standards of measurement of rate of flow by rise of surface; circulating pumps with a constant-head water-tower; and means for the distant indication and recording of hydraulic potential in the sand body. Provision is made for the subdivision of the sand tank and also of the area sprayed, so that a constant depth of sand may be made to represent greater depths by working to smaller scale.

The propriety of using structureless sand to represent what may well be structured soil is explained; the sand and the soil are regarded as permeable media with measurable permeabilities without distinction between causes of such permeability. The solution of problems in the sand tank can be equated to those in natural materials with the same boundary conditions, provided that the ratio of permeability to velocity of flow of fluid at corresponding points is the same in both cases. The use of sand of high permeability has the advantages both of uniformity and rapid settling, and that it requires high rates of artificial rainfall, which are more readily controlled than low rates.

The system of potential recording is described.

1171* COLLIS-GEORGE, N.

Calculation of the Permeability of Porous Media from their Moisture Characteristics.

Trans. Amer. Geophys. Un. 1953, **34**, 589-93.

An interpretation of the moisture characteristic, or moisture content—hydrostatic pressure deficiency relationship, of a porous medium is outlined, giving the pore size distributions involved in the simultaneous flow of a wetting and a non-wetting fluid.

A method is described of calculating intrinsic permeabilities to air and water flow at all fluid contents.

1139* COLLIS-GEORGE, N.

A Note on the Pressure Plate-Membrane Apparatus.

Soil Sci. 1952, **74**, 315-22.

Results are given to show that the moisture content of a soil in a pressure plate apparatus decreases indefinitely when a dry gas is used and gaseous diffusion through the membrane is continuous.

It is pointed out that for any soil sample there is only one water vapor pressure of the applied gas which can be in thermodynamic equilibrium with the sample. This vapor pressure depends on the osmotic pressure of the soil solution and the pressure of the gas applied.

From the literature, it would appear that generally the moisture content of the sample is determined for a given pressure when the outflow of liquid water through the membrane has become negligible. It is suggested

that this condition be called a "time equilibrium", which will vary with the time of pressure application. It is further suggested that the condition under which the humidity of the gas leaving the apparatus is the same as that entering be called "hydraulic equilibrium". Except for multisoil apparatus, this equilibrium will be thermo-dynamically true and the relative humidity involved will be the one in equilibrium with both applied pressure and osmotic pressure. True hydrostatic equilibrium can be reached only with an ideal membrane that is permeable to water but completely impermeable to gases.

Under the conditions of hydraulic equilibrium and ideally of hydrostatic equilibrium, it is possible to relate a given moisture content to a given applied pressure with no ambiguity.

The requirements for hydraulic equilibrium are outlined and examples of deviations from these requirements are given.

It is pointed out that the difference between "time" and "hydraulic" equilibria has not yet been investigated, but depending on the subsequent use made of the results, the difference may not justify changes in existing procedures. It is suggested that precise experimental conditions be included when results for pressure plate-membrane apparatus are reported.

1148* NICHOLSON, H. H. & FIRTH, D. H.

The Effect of Ground Water-level on the Performance and Yield of Some Common Crops.

J. Agric. Sci. 1953, **43**, 95-104.

The results obtained during the development of a field experiment (already described) on peat soil are summarised. The observations were made on a series of common crops growing in rotation over a range of static ground water levels. The crops used, wheat, rye, ryegrass, potatoes, sugar beet, kale and celery reacted differently to the ground water conditions, and the seasonal incidence of rain had an overriding influence on their performance. The ground water-level appeared to operate in most cases directly on the growth and development of a crop but occasionally indirectly through such factors as weed infestation, difficulties of cultivation or the incidence of disease. Specific examples are described and discussed.

1179* NICHOLSON, H. H., FIRTH, D. H., EDEN, A., ALDERMAN, G., BAKER, C. J. L. & HEIMBERG, M.

Effect of Ground Water-level on Fenland Grass.

J. Agric. Sci. 1953, **43**, 265-74.

Further studies were carried out during 1950 on the effects of different ground water-levels upon the productivity and composition of Italian rye-grass grown on a calcareous light peat soil. The season was an unusually wet one, in contrast with the dry season experienced in 1949.

Seven successive cuts were taken during the season from each of two crops of ryegrass, one following a crop of marrow-stem kale, and the other a crop of celery. Different amounts of a general compound fertilizer had been applied.

Generally, the findings confirmed those of the previous year's investigation. High ground-water level (approximately 18 in. below ground surface) had a deleterious effect upon the yield and quality of ryegrass as reflected by its protein content, compared with the medium and low water-levels (23 and 30 in. below ground surface, respectively).

The high water-level also had a depressing effect upon the percentage of potassium and magnesium in the grass, but had no consistent effect upon calcium and phosphorus. The silica content rose steadily in all cases as the season advanced, as occurred in the previous year.

Residual manuring effects were well marked in the crop following celery. The total yields of dry matter from the medium and low water-levels considerably exceeded those of similar plots following kale, and the protein contents were also appreciably higher. This demonstrates the advantages of a high soil nutrient status, under conditions of suitable water-levels, for a crop of fenland grass.

A high water-level inhibited growth and quality, irrespective of the nutrient status of the soil.

NICHOLSON, H. H.

Principles of Field Drainage. 2nd ed. Pp. xi+163, with 12 Plates and 29 Figs.

Camb. Univ. Press, 1953. 18s.

OTHER PAPERS

NICHOLSON, H. H. **Fundamental Problems of Land Drainage.** *Pwr Fmr.* 1952, **9**, 156-8.

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NICHOLSON, H. H. **Tile Draining.** *Pwr Fmr.* 1953, **10**, 126-8.

STATISTICS

1158* WISHART, J.

The Teaching of Statistics.

J. Ass. Inc. Statist. 1952, **3** (3), 3-10.

This paper is the printed record of a lecture given to the Association of Incorporated Statisticians at their Oxford Conference in 1952, and deals with some of the problems met with in the training of statisticians, particularly those intended for careers in industry. The occasion was taken to summarize the discussion which took place on the subject in Cambridge in 1951 during a Conference of the Royal Statistical Society.

1168* WISHART, J.

The Combinatorial Development of the Cumulants of the k -Statistics.

Trab. Estadist. 1952, **3**, 13-26.

A combinatorial method for working out the cumulants of the multi-variate distribution of the k -statistics was developed by R. A. Fisher in 1929. The method proved to be very much more expeditious, in the hands of the expert, than the corresponding algebraic method, which becomes very complex for higher order results. It has, however, been criticized on the ground that the ordinary user has a liability to error that he is likely to remain free from if he restricts himself to the beaten track of straight-forward algebra. Errors may arise in enumerating the patterns which exist, and also in assigning them numerical co-efficients. In the present paper the problem has been tackled afresh in the light of knowledge gained through the use of the recently introduced generalised k -statistics. It is now possible to determine in advance the sum of the numerical coefficients of the patterns relating to individual terms of the required formula, and also to develop later terms from earlier ones in an exact manner. This seems to ensure that all patterns are correctly enumerated, at a cost of including, at first, more patterns than are required, for some will have zero coefficients. The method is illustrated on a few examples, and in the process of one of the more complex of the formulae, which has been wrong up to now in the literature, is put right.

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